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Climate change adaptation in vulnerable crop and livestock production systems in Mgeta, Tanzania

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Introduction

Awareness regarding effects of climate change on the environment and livelihoods is becoming more apparent than at any time before (Elisha, 2006). Among the farming systems that have attracted the attention in Tanzania, are those in Mgeta in the high altitude water catchment area in the Uluguru Mountains. Land degradation have been widely reported in Mgeta (Ponte, 2001), and is currently threatening the source of water for domestic use and livelihoods of the local communities. Increased occurrence of droughts and dry spells during the growing seasons might reinforce the problem. A robust cropping system to replace the erosion vulnerable vegetables seems needed if agriculture is to persist in the area. Farmers in Mgeta grow vegetables in pure stand and in intercropping systems on bench terraces and in steep slopes, especially tomatoes, potatoes, cabbage, beans, green peas and maize. Besides, traditional goats (free roaming) and pigs are kept for meat and manure for the vegetables. In 1988, Norwegian dairy goats were introduced and currently farmers upgrade the local goats by crossing with dairy bucks. The dairy goats are tethered or kept indoors to avoid land degradation due to overgrazing. Expanding goat milk production might be advantageous since a market for milk, or milk products such as yoghurt, can be found both locally and in the neighboring towns. In this paper a traditional cropping-livestock system with meat goats and pigs and extensive vegetable production is compared with dairy goats and more use of multi-purpose trees (MPTs) and grass and less vegetables.

Materials and Methods

Interviews with 60 farmers, guided by a pretested questionnaire, were conducted in five wards of the Mgeta division in July and August 2012. The data collected included household information, parcel characteristics, crop and livestock production characteristics, and labor requirements. The values obtained were used to parameterize a linear programming model:

$$\text{Max } Z = c'x, \text{ subject to } Ax < b, x \geq 0, \quad (1)$$

where: Z is farm gross margin (GM), c' is a vector of marginal activity GMs, x is a vector of activity levels, A is a matrix of activity resource requirements, and b denotes a vector of resources.

Activities for tomatoes, potatoes and cabbage as well as N-fixing beans and green peas were developed for the rain (270 days from September to May), and dry (95 days from June to August) periods. The crops were grown under fruit trees, one fruit tree (plums) per 100m^2. Intercropping was assumed for potatoes and green peas on homestead area (2,093 m^2) and for maize and beans in the distant area (3,475 m^2). The family's own needs require 10% of the homestead area for tomatoes and potatoes and another 5% for cabbage. Separate constraints balance the supplies and use of purchased fertilizers and farm produced manure. The GMs were calculated in the 2012 price level with yields, prices, and work requirements according to season.

The pigs use leftovers including some of the yields from tomatoes, potatoes and fruits while other crop leftovers were used by the goats. The goats utilize grass, leaves, and branches of multipurpose trees, particularly Mulberry and L*eucaena leucocephala* grown on homestead or communal land (418 m^2). Maize bran can be purchased for supplementary feeding. All feeding values were based on Soleiman (2010) e.g. 192 MJ of energy from 10m^2 of grass and MPTs. The feeding of dairy goats encompass five constraints, energy and protein requirements for milk production in the two seasons, and a constraint for maintenance feed which was assumed provided by grass and MPTs. Based on Soleiman (2010) daily maintenance feed for dairy goats was calculated to 9.4 MJ of energy (50% for replacement kids) and production feed for milk to 19.9 MJ and 130 gram of protein. For meat goats values for maintenance and growth were 30% lower. For pigs

35.2 MJ of energy and 155 gram of protein are assumed for maintenance and growth. The replacement rate was 0.4 for goats while piglets are purchased.
In a basic scenario all crop yields were normally distributed with SD=10%. In the climate change scenario the yields were lowered by 10% for vegetables and by 5% for the grass and MPTs since open field vegetables are especially exposed to drought following higher temperatures. The SDs would increase to 20% for crops and to 15% on grass and MPTs. The MPT system was assumed less affected since the tree canopy will limit evaporation and risk of landslides when heavy rain follows a prolonged period of drought in the steep slopes in Mgeta. The model was specified and solved in Excel, supported with Simetar (Richardson *et al*., 2008) to undertake a risk analysis.

Results and Discussion
The results demonstrate extensive vegetable cropping in a basic scenario without dairy goats (Table 1). Meat goats are only profitable when utilizing communal land and farmers will keep pigs to utilize crop leftovers. The number of pigs depends on the amounts of crop leftovers, the calculations resulted in less than 0.5 pigs. When dairy goats are permitted the amounts of grass and MPTs increase and farmers also purchase considerable amounts of maize bran for the goats. Due to the need for feed, the cultivation of vegetables declines to what is necessary to provide for the needs of the farming family. Evidently, alternatives with dairy goats do better in both scenarios, in particular under climate change +21.4% compared to +13.8% in the basic scenario.

Table 1: Model solutions with and without dairy goats in a basic compared to a climate change scenario

	Land use*, m^2					Grass &	Goats			Feeds,	Farm GM,
Scenario	**T**	**P**	**C**	**B**	**MB**	**MPTs**	**Dairy**	**Meat**	**Pigs**	**TZS**	**TZS**
Basic											
Without dairy goats	2512	1423	251	2412	3831	419	0	3	0	0	1644 461
With dairy goats	502	1005	251	2119	2617	1633	8	0	0	1581 610	1871 378
Climate change											
Without dairy goats	2512	1423	251	968	2236	419	0	3	0	0	1487 230
With dairy goats	502	1005	251	565	954	1633	8	0	0	1584 286	1805 026

*T= Tomatoes, P=Potatoes and green Peas intercropped, C=Cabbage, B=Beans and MB= Maize and Beans intercropped (distant land)

The probability density functions (PDFs) of the farm GM (Fig. 1) indicate that one should expect considerably more income variations for vegetable production, compared to dairy goats. Change in length of growing season, extended drought, shortage of water for irrigation, and increase in crop diseases are some of the many suggested causes for the variation (Thornton *et al*., 2009).

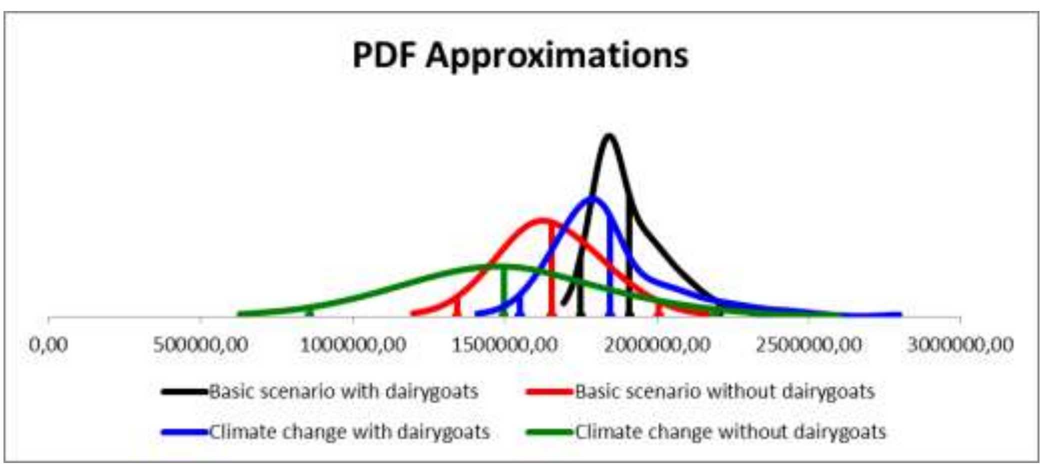

Fig. 1: Probability density functions of farm GM (TZS) in the basic (BS) and climate change (CCS) scenarios.

Keeping dairy goats to improve food security and livelihood in vulnerable communities like Mgeta may, under certain constraints regarding grazing and browsing behaviour, provide opportunities for more environmentally friendly use of farmland compared to vegetable cultivation or free browsing meat goats. Considering that Mgeta has a potential as water catchment area, intensifying dairy goat farming could be the best option to provide livelihood needs and more sustainable use of natural resources and reduce pressure on land and water.

A shift from crop-livestock to intensive dairy goat production would however require improved breeding, feeding, and disease control, accompanied by fodder production and planting of multipurpose trees. In so doing productivity would likely increase enabling the household purchasing power to improve, and facilitate a transfer to more market economy. Adoption of new management practices could be somehow difficult but gradually the system should stabilize at the micro level. However, literature suggests that transformation cannot happen automatically but would require different approaches with both technology dimensions; policy and market solutions for those involved.

Policy measures to promote or enhance more dairy goats could include such measures as subsidies for increased concentrate feed purchase, investment support for developing e.g. yoghurt production or other milk processing, or subsidy payment for permanent grassland and MPTs. Moreover, the National Public Private Partnership policy opens up for more opportunities for partnerships with *e.g*. Shambani Graduates to invest along the milk value chain. However, it remains debatable whether the people in Mgeta would capitalize their struggles for better livelihood and sustainable use of scarce natural resources through escalating dairy goat production.

Conclusion

The study indicates that a changeover from a seasonal vegetable crop system to dairy goats with permanent grass and multipurpose fodder trees would increase farm gross margin by roughly 14% in Mgeta. Dairy goats seem to do better under climate change as farm GM declines by 3.5% compared to 9.6% without dairy goats. Perennial grasses under a tree canopy are likely to be less affected by climate change compared to seasonal vegetables favoring the goat system.

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